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Petra M. Bosch-Sijtsema*[1], Pernilla Gluch[1] & Ahmet Anil Sezer[2]

*Corresponding Author

[1]Chalmers University of Technology, Department of Technology, Management and Economics, Division Service Management and Logistics. Vera Sandbergs Allé 8, SE-412 96 Gothenburg, Sweden. petra.bosch@Chalmers.se, pernilla.gluch@chalmers.se.

[2]Chalmers University of Technology, Department of Architecture and Civil Engineering, Division Construction Management, Sven Hultinsgata 6, SE-412 96 Gothenburg, Sweden. ahmeta@chalmers.se.

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Abstract

The implementation of building information modeling (BIM) has resulted in the development of new roles for BIM actors, but few empirical studies have been conducted on how these roles develop professionally. The present study investigates the professional development of the BIM actor and how this role is perceived by BIM actors and non-BIM actors in Sweden. The study uses a questionnaire (N=342) in eight companies, comprised of contractors, architects, and clients. The BIM and non-BIM actors were compared on similarities and significant differences in their characteristics, tasks, experience, education, and barriers to the role's development. We found that BIM actors perceive their role, characteristics, tasks and education as coordinating and driving change. However, non-BIM actors perceive the BIM actor role as focusing more on technical skills than on softer skills. The perceptions of the two groups indicate possible tensions toward the future professional development of the BIM actor role.

Key-words: Building Information Modeling (BIM), BIM actor, BIM coordinator, professionalization, AEC industry Sweden, survey

1 Introduction

The implementation of building information modeling (BIM) has resulted in the development of new work practices, roles and responsibilities related to the new technology [1,2,3,4,5]. The literature has identified BIM actor roles as relevant for successful BIM project implementation and these roles include not only technical competencies, but also skills related

to process change and management [6,7,8]. In a recent study, Uhm et al. [7] analyzed job advertisements of BIM roles and found that 35 different job titles were used with different responsibilities and tasks. Another similar study by Davies et al. [6] focused on how the roles and responsibilities of BIM actors were defined in documents and national/international BIM guidelines and handbooks. Both studies discuss that there is a development of a standardized BIM practice, but that the development of the role is uncoordinated and that the role and its responsibilities would require further attention for the development of BIM roles. Previous studies have discussed the emerging new role of the BIM actor on a conceptual level [2,3,4,5] or as a review [8], but there is a lack of empirical studies on this new role, its characteristics, tasks, perceived responsibilities, and development as an established professional role in the Architecture, Engineering and Construction (AEC) industry.

Although recent studies have shown the international emergence of three roles as BIM actors (namely, BIM manager, BIM coordinator, and BIM modeler), there has been scant research on the forming of BIM related roles, their particular tasks as well, and how BIM actors are perceived by other actors in the industry. Therefore, the present study is interested in studying the development of the BIM actor from a professionalization perspective. The development of a particular role is based on behavior that is expected in the particular social context of a role, which can indicate a status or particular position [9]. Such a role is often determined by its relation to other roles, as well as how other individuals see the particular role. Earlier studies on BIM roles show a clear difference in the use of roles, the naming of BIM roles, and role descriptions [6,7].

The following research questions form the basis of our work: How does the BIM actor develop as a professional role and how is this role perceived by the BIM actors that have a specified role or task related to BIM? How is the BIM actor role perceived by other actors that collaborate with BIM actors (non-BIM actors)? Comparing the insiders' and the outsiders' perspectives on the BIM actor's role may enable us to reveal some of the tensions that both hinder and stimulate the development of the professional roles related to BIM practices. The comparison includes different aspects: characteristics expected from BIM actors, tasks of BIM actors, experience and education expected for BIM actors and barriers to development of a BIM actor role.

The theoretical framework and theoretical assumptions of the study are discussed below. The method section presents the empirical data collection and survey, as well as the methods applied for the analysis. The findings section shows the main findings based on the

earlier assumptions and these are discussed and related back to literature in the final discussion and conclusion section.

2 Theoretical framework

To study the development of the BIM actor role and relate this to non-BIM actors, a professionalization perspective is applied. A professional role encompasses a subset of occupations [10]. The literature perceives occupations as social entities in that they are socially constructed as "reality" through patterns of human interaction over time [11]. According to Anteby et al. [10], occupations are socially constructed entities that include: (a) the category of work; (b) the actors that have been identified, either by themselves or by others, as members and practitioners of this work; (c) the actions enacting the role of occupational members; and (d) the structural and cultural systems upholding the occupation.

The theoretical perspective applied in this research is that roles are dynamic and are continuously developing and changing. Professional roles are developed through ongoing social processes of interactions between individuals, artifacts, and the institutional context in which they are embedded [12,13,14]. The institutional context in this case is the way of working, regulations, norms, and informal rules for construction projects in the AEC industry. Professional groups are affected by the institution they work in, and they also impact institutions by routines and procedures that are beneficial for them [15]. Suddaby and Viale [16, p. 426] noted that "projects of professionalization and institutionalization occur simultaneously". A professional role can only become institutionalized when this is an accepted role within the industry, implying that the industry recognizes this professional role and its tasks and responsibilities. Tasks of professionals are progressing through new technological developments within an industry, new standards, as well as new educational programs and professional networks. Thus, professional roles are not independent stand-alone roles, but are dependent on the expectation of both the professionals as well as the surroundings that work with the professional roles. In such a way, roles can act as a part of the meaning-making process of developing professional identities [17].

For the development of a professional role and identity, there are multiple relevant aspects: (1) personal characteristics and expectations on a particular role engagement; (2) expectations of education and experience for such a role – the actors identified as practitioners working with BIM themselves, but also by others [10]; (3) the actions enacting the role in terms of expectations on task performed by such a role; and (4) the structural and cultural systems upholding the occupation in terms of the support and definition of such a role by the senior

management, future development expectations of a role within the industry and perceived hindrances towards such a role development. Researchers focusing on BIM and BIM roles have categorized the first three above-mentioned categories under competence of a role [see 7,18]. In the present paper we apply the same categorization and divide the aspects relevant for the development of a BIM role into two parts: (A) expected competences concerning characteristics, education, experience, and practiced tasks from a BIM actor by BIM actors themselves and non-BIM actors; and (B) the structural and organizational systems that influence the professionalization of the BIM actor role.

2.1 Competency expectations of BIM actors

Studies that focus on the BIM actor role have discussed different forms of competency on the individual level [7,18]. Competency is defined as an individual's ability to perform a specific task or deliver a measurable outcome [18]. The cited authors view competency in terms of (1) personal traits like attitude or behavior; (2) knowledge – conceptual and theoretical; and (3) skill – procedural and applied knowledge. These three parts of competency are discussed below in terms of BIM actor characteristics, which are related to personal traits; BIM actor education and experience, which are related to knowledge and partly skills; and task expectations, which are related to applied knowledge and skills.

2.1.1 BIM actor characteristics

When discussing identity in relation to professional roles, it becomes relevant to discuss the characteristics of the bearer of the role. An important element of the professional role is the emotional and personality characteristics. According to the literature, professional roles are shaped by how they conduct their work tasks; that is, professionalism in terms of engagement, ethical conduct, and attitude are related to a professional identity [19]. Therefore, the elements important for a particular role, the engagement and motivation to participate in a role become relevant to shaping a professional identity. The expectations on characteristics are also reflected in the work of Succar et al. [18] and Uhm et al. [7], who perceived that one part of the competency of BIM actors is related to personal traits like attitude or behavior. Therefore, we assume that the expectations people have regarding the individuals who hold a BIM actor role of both BIM actors, as well as others working closely with BIM actors, offer insights into the role characteristics of BIM actors.

2.1.2 Expectations on education and experience

The main elements of professions are the use of specialized forms of knowledge in their work, which are often based on formal and academic credentials [15]. Education, including academic

education, is perceived as an important element of a profession. Within the construction industry, studies have discussed that for particular roles and professions experience is more focused on than on education. Löwstedt and Räisänen [20] discussed that especially on-site experience is valued highly might prevent new competencies from coming into the organization. Comparatively, studies related to the use and implementation of BIM have advocated the need for education, and particularly university education [21]. The need for education is associated with overcoming the obstacles of implementing BIM and working with BIM [22] and is connected to the skills, practices, and theoretical knowledge needed to develop BIM competency [7,18]. Therefore, we assume that, for the professional identity of BIM actors, education and construction experience are both relevant from the perspective of BIM actors as well as others.

2.1.3 Task expectations

The professional role is often connected to what a professional engages in – their tasks and activities [22]. The task can be related to knowledge work especially in the case of a BIM actor, in terms of problem-solving skills and conformity to a code of ethics performed in a particular knowledge domain or expertise area. In relation to the role of the BIM actor, a number of tasks have been defined from literature in relation to BIM activities (see Table 1). Several activities have been defined in the literature; for example, Cao et al. [24] identified 13 applications for BIM in the design and construction stage. In the case of the BIM actor, certain kinds of tasks are commonly referred to in the literature, including clash detection, quantity surveying, and developing 3D models [see 24, 25, 26, 27]. These common tasks can support the formulation of an expertise or knowledge domain in the field [cf. 15]. While these tasks are connected to BIM usage, it becomes relevant for the development of the profession of a BIM actor to understand what tasks they are primarily performing or what they are expected to perform. Recent studies found that BIM roles can be on both the project and organizational levels and have different tasks on these levels [6,7]. Therefore, we assume that in order to develop a professional role of BIM actor there must be coherence in task expectation from BIM actors themselves and from others.

Table 1: BIM-related tasks mentioned in survey studies

BIM Usage	**References**
Developing/designing a 3D model	[28,29]
Clash detection/design reviews	[8,24,25,26,27,28]
Coordination of model/between different actors	[6,8,25,29]
Coordinate between contractors and subcontractors	[6]
Ensure quality control	[6]
Visualization/3D presentation	[24,25,26,27,28]

Building design	[28]
As-built model	[28]
Quantity take-off	[24,25,26,29,30]
Site utilization planning	[24,26]
Site logistics	[24,26]
Cost estimation	[24,25,26,27,28]
Schedule time planning	[24,25,26,27,29]
Prepare for facility management	[26,28]
Generation of procurement plans	[26,27]
Resource plans/staffing plans	[24,25,26]

2.2 Structural and cultural systems upholding the BIM actor role

In relation to the company definition of a professional role of the BIM actor, it also becomes relevant to gain an understanding of the future development of such a role. Do the employees and industry perceive that there is a future for the role of the BIM actors and are there possibilities for career development within such a role? The literature has been very positive on the development of new roles like the BIM manager, BIM strategist, BIM coordinator, and BIM modeler [see 4, 5, 6, 7, 8, 26]. However, it is also clear from other studies that roles are defined and developed differently in the industry and in different countries [6,7,8]. Therefore, we assume that the relevance of a possible future of a BIM actor becomes important for the identity and professional development of such a role.

While a professional role is usually defined in a particular industry and can be certified or institutionalized within an industry, the company's terminology, definition, and attention toward a professional role are relevant for its development and institutionalization. Therefore, we assume that the extent to which the company has defined the role of the BIM coordinator within a firm has implications for the institutionalization and development of such a role.

Furthermore, articles discuss the structural and organizational hindrances in relation to professional role development [see 31]. Some of these hindrances are also discussed for the development of BIM and the BIM actor role. For example, the lack of competence within knowledge of BIM and usage of BIM has been mentioned in the literature as a major hindrance for the implementation of BIM [25]. Concerning knowledge development, a study on IT in construction in Sweden showed that there were large gaps between experts in IT and actors who have less knowledge concerning IT use and benefits [32]. Other authors have discussed the resistance to change to adopt new technology in the construction industry [33, 34]. Studies that have mentioned the gaps of knowledge and competence between BIM experts and non-BIM actors have shown the relevance of studying the professional development of BIM actor roles from the perspectives of both the BIM actor and the non-BIM actor [e.g., 1, 8, 25]. In such a

way, tensions between the perceptions of these two groups in relation to the role development can be found [cf., 10]. Some of these tensions can come from the way the AEC industry is organized. The AEC industry has been characterized as having difficulties to align corporate organizational structures and long-term strategies with temporary project organizations [12, 35, 36]. The imbalance between long-term concerns and short-term project focus also has implications between project practices and professional role development [cf. 37]. For example, new roles that develop outside of the traditional roles in the AEC industry, such as environmental professionals, have been reported to struggle to develop their professional identity and role [38]. Also, in roles that are developed to bridge construction boundaries by combining processes, actors such as partnering managers, logistic managers and BIM coordinators are found to create tensions and disruptions when practicing their work [39]. Other common hindrances for learning in project-based organizations are the lack of experience feedback and lack of cooperation between projects. We assume that structural and cultural systems can uphold the professionalization of the BIM actor role.

3 Research Method

3.1 Data collection

The questionnaire was sent out through a web-based survey program and focused on the emerging professional role of the BIM actor. The questionnaire was distributed to 631 employees in eight AEC companies (contractors, architects, and clients/owners) in Sweden. The questionnaire consisted of 20 main questions in four sections. Questions were based on the literature presented in the theoretical framework as well as previous studies by the authors and interviews conducted with a number of actors before the questionnaire was sent out. In total, 12 interviews were conducted with contractors (seven), architects (three), and clients (two) before we designed the questionnaire. The interviews provided insights into the different BIM actor roles and the development of these roles. Besides the questions based on literature and interviews, some questions in the survey were developed in cooperation with the involved companies in order to fit the questionnaire to the context of the respondents. Each company had the opportunity to adapt the questionnaire regarding terminology it uses for BIM and the naming of particular functions. The first part of the questionnaire focused on the respondents' background in terms of gender, age, role, and education, as well as a general question regarding what they perceived as attractive in a profession. The second part focused on the experiences of working with BIM in both the company as well as in construction projects and the amount

of time people worked with BIM, on a scale of 0–100 percent. The third part specifically asked about the role of the BIM actor in terms of their tasks, perceived characteristics, education, and experience, and the role's importance for project success and how the role is defined in the company. The final part of the questionnaire looked more at future barriers for the development of the role and the perceived future development of the role; respondents also had the opportunity to reflect on the role in written text – 194 open answers were given. Perceptions of the respondents in the third and fourth part of the questionnaire were measured on a six-point Likert scale.

Due to the emergent nature of the topic, purposeful sampling was used. The companies were selected specifically because they had either been in the news for their knowledge concerning BIM, they were known to have performed BIM projects, or were represented in multiple network activities concerning BIM. The contractor and architect firms are relatively mature in their BIM usage and not only use 3D modeling but also multiple simulation and analytical technologies in combination with integrated processes. The selected companies represent large and small-and–medium-sized companies, which is a good representation of the Swedish market with many small and medium-sized AEC firms. Table 2 shows the size of the firms in terms of number of employees. The selection criteria for the sample were that respondents worked with BIM or have worked together with BIM actors or in construction projects where BIM was used. This selection also included respondents who had limited work experience with BIM. For the purposeful sampling, the researchers relied on the companies to make an appropriate selection. In the architect firms the questionnaire was sent out to all employees, including those with no BIM experience. In addition, the questionnaire was pre-tested by one or two people in each company. Since job titles used for BIM actors are diverse, a general description was used in which all professional roles with an expressed task to manage and/or work with BIM/virtual design and construction (VDC) and/or BIM/VDC-related development were included; these were BIM coordinators, specialists, experts, and managers among others. This extended perspective was explained in the questionnaire instructions. The clear-cut role of BIM modeler [e.g., 6], as found internationally, was not used in any of these firms. Two roles emerged clearly from the survey: that of BIM strategist/specialist/responsible and that of the BIM coordinator. The BIM strategist/specialist is comparable to a BIM manager as used in other countries. These roles are in line with the roles defined by BIM Alliance Sweden [40]. The questionnaire and two reminders were sent by email.

In total, 342 responses to the questionnaire were received (53.7 percent response rate); see also Table 2. The responses came from three different groups: contractor firms (65 percent), architecture firms (26 percent), and clients/owners (9 percent). Around 30 percent of the respondents (N=104) could be labeled BIM actors (that is, coordinators, strategists, or specialists) as they were assigned, fulltime or part time, a specific BIM function in the company. Seventy-eight percent of the total respondents were male. Around half of the respondents (47 percent) were aged 30–44, about one-quarter (23 percent) were under 30 years, another quarter (27 percent) were aged 45–59, and only 3 percent were above 60. Seventy-five percent stated that they have a university education.

Table 2. Overview of collected data.

Case no.	**Type firm**	**No. of employees**	**Survey***	**Open answers survey**	**Interviews before survey**
Case 1	Contractor	>17,500	N=173 R=102 (59%)	41	3
Case 2	Contractor	>14,500	N=74 R= 46 (62%)	38	
Case 3	Contractor	>8000	N=109 R=73 (67%)	47	4
Case 4	Architect	>160	N=115 R=45 (39%)	22	3
Case 5	Architect	>150	N= 110 R= 46 (42%)	31	
Case 6	Client/owner (public)	>440	N=26 R=13 (50%)	9	2
Case 7	Client/owner (private)	>380	N= 7 R=4 (57%)	5	
Case 8	Client/owner (private)	>300	N=18 R=13 (72%)	1	
8 firms			***N=631 /R=342 (54%)***	***194***	***12***

**N=total number of people the survey was sent to; R= total number of people who responded*

The type of company differed between BIM and non-BIM actors: 36 percent of the contractor respondents, 19 percent of the architect respondents and 23 percent of the client respondents worked actively with BIM. The percentage of BIM actors was higher for younger respondents: 56 percent of respondents aged under 29 were BIM actors, compared with 29 percent of respondents aged 30–44, 18 percent of respondents were aged 45–59 years old, and 13 percent of respondents older than 60. All items included in the test can be found in Table 3.

Table 3: All items included in the questionnaire analysis.

Characteristics

Outgoing; has good communication skills; driving; has leadership qualities; shows commitment; has good cooperative skills; pedagogical; has good problem-solving skills; diplomatic; able to make demands; patient; has a critical approach; curious; able to handle criticism; structured; change-oriented; flexible; strategic
Education, understanding and experience
Understands the construction process; understands different professional groups' needs; experience with design; experience with production; experience with project management; experience with 3D modeling; Worked with computer technology/IT; architectural education; civil engineering education; construction engineering education; computer engineering/ IT education; 3D modeling education
Tasks
Create virtual model of completed building; establish and maintain coordination model; quality control of the model; quantity take-off; manage model-based information; simulate scheduling; simulate workplace disposition; cost estimation; collision check; prepare the model for the management phase; create a basis for risk analysis; simulate building logistics; create support for project follow-up; simulate staffing plans; establish BIM action plans; set up BIM requirements; maintain BIM requirements; set goals; manage goals; determine metrics; manage metrics; participate in consultancy procurement; coordinate delivery to customer; quality assurance delivery to customer; compile BIM experiences from the project; facilitate communication in projects; create information channels between involved actors; support cooperation through visualization of the model; coordinate building designers (consultants); coordinate contractors
Perceptions on the development of the role
BIM actor is a significant role for the success of a project; How do you think the BIM role will be developed in the future?
Definition
My company clearly defined what a BIM actor should do in a project.
Barriers
Insufficient management support; lack of financial resources; lack of time; lack of experience at BIM actors; lack of knowledge of other employees about BIM; lack of educational opportunities; lack of cooperation between projects; lack of experience feedback; lack of organizational structure; opposing organizational culture; unclear distribution of responsibilities; unclear career development; lack of supportive strategic decisions

3.2 Analysis

The data analysis in this paper began with the Kolmogorov-Smirnov test, which was used to check whether the data distribution is normal and the results of the test indicated violation of the assumption of normality for most of the variables. Hence nonparametric methods were employed.

The second test was the Mann-Whitney test, which analyzes whether two independent samples differ significantly from each other by comparing the data from these samples. In this paper, the Mann-Whitney test was used to make comparisons between two groups: BIM actors and non-BIM actors. The BIM actors consist of 18 BIM strategists/specialists (13.6 percent) and 58 BIM coordinators (43.9 percent), while a third group of 28 people indicated that they were both BIM strategists and coordinators (21.2 percent). The reason why some people might work as both BIM coordinator and strategist can be related to the size of the firm – smaller firms have BIM actors that perform multiple tasks. The three groups are treated as one group of BIM actors mainly due to the fact that their answers did not differ greatly and many of these actors only worked for a certain percentage with BIM-related tasks. The respondents who

worked more than 50 percent of their working time with BIM questions were the following: seven out of 18 BIM strategists, eight out of 58 BIM coordinators, and 10 out of 28 respondents who worked both as BIM strategist and BIM coordinator. Many actors also had other roles, such as project managers, design managers, or architects. Where there is a significant difference in the answers of the BIM strategist/specialist and BIM coordinator, this is mentioned in the findings.

4 Findings

This section presents results of the comparison between BIM actors (n=104) and non-BIM actors (n=238). The BIM actors were selected from a question concerning respondents' current role. The BIM and non-BIM actors were compared in order to analyze whether these two groups had significantly different opinions about characteristics expected from BIM actors, tasks of BIM actors, experience and education expected from a BIM actor, and barriers to the development of a BIM actor professional. By comparing BIM and Non-BIM actors, the study could compare whether both groups had either a similar perspective on the role of the BIM actor or if there were differences in perspective that could account for possible tensions for future role development.

4.1 BIM actor characteristics

Concerning expectations of the characteristics of a BIM actor, respondents had relatively similar expectations and portrayed high expectations on the characteristics of a BIM actor (see Table 4), especially in terms of having good interpersonal skills, showing commitment, and being structured – those were the three characteristics that BIM and non-BIM users valued most highly. There were no significant differences between the responses of BIM strategists and BIM coordinators. However, there were some significantly different opinions between the BIM and non-BIM actors on the characteristics expected from BIM actors. BIM actors, more than non-BIM actors, expect that a BIM actor should have good communication skills, have a strong driving force, and be able to make demands, patient, curious, and change-oriented.

Table 4. The means and Mann-Whitney test for characteristics of a BIM actor.

Characteristics	Role	Mean values	Mean ranks	p-value
Have good interpersonal Skills	BIM	5.50	155.68	0.056
	Non-BIM	5.27	137.85	
Shows commitment	BIM	5.41	154.33	0.094
	Non-BIM	5.20	138.56	
Structured	BIM	5.35	145.06	0.863
	Non-BIM	5.27	143.44	
Has good communication Skills	BIM	5.33	158.16	0.023*
	Non-BIM	5.03	136.54	

Pedagogical	BIM	5.22	153.49	0.132
	Non-BIM	5.01	139.00	
Able to make demands	BIM	5.22	163.23	0.003*
	Non-BIM	4.84	133.87	
Curious	BIM	5.16	159.61	0.015*
	Non-BIM	4.80	135.78	
Change-oriented	BIM	5.15	158.88	0.019*
	Non-BIM	4.87	136.16	
Flexible	BIM	5.11	151.72	0.225
	Non-BIM	4.92	139.93	
Driving	BIM	5.11	157.03	0.033*
	Non-BIM	4.87	136.45	
Has patience	BIM	5.03	156.80	0.046*
	Non-BIM	4.76	137.26	
Has good problem solving skills	BIM	4.89	143.88	0.985
	Non-BIM	4.82	144.06	
Strategic	BIM	4.85	104.75	0.623
	Non-BIM	4.75	100.65	
Has the ability to handle criticism	BIM	4.71	151.31	0.226
	Non-BIM	4.53	139.36	
Has a critical approach	BIM	4.67	111.66	0.084
	Non-BIM	4.46	97.24	
Outgoing	BIM	4.53	155.08	0.088
	Non-BIM	4.27	138.17	
Diplomatic	BIM	4.43	152.08	0.214
	Non-BIM	4.20	139.74	
Has leadership qualities	BIM	4.19	144.10	0.988
	Non-BIM	4.16	143.95	

** Test is significant at p-value (probability value) <0.05*

4.2 Experience and education

In terms of experience and education, all respondents considered that understanding of the construction process was especially important (see Table 5). BIM actors felt that understanding of different professional group's needs was in second place, while non-BIM actors ranked experience from 3D modeling in second place. Education was generally perceived as less important. According to the Mann-Whitney test results, BIM and non-BIM actors had significantly different perceptions regarding the BIM actors' need for experience from 3D modeling and education in computer engineering/IT. Non-BIM actors expected, to a greater degree than BIM actors, that a BIM actor should have experience from 3D modeling and education in computer engineering and IT. Between the BIM strategist and BIM coordinator there are significant differences for two items: the BIM strategist perceived that experience as well as education with computer technology/IT were more important than for the BIM coordinator.

Table 5. The means and Mann-Whitney test for experiences and education a BIM actor should have.

Experience and education	Role	Mean values	Mean ranks	p-value
Understanding of the construction process	BIM	5.35	138.31	0.433
	Non-BIM	5.41	145.46	
Understanding of different professional group's needs	BIM	5.25	150.43	0.236
	Non-BIM	5.04	139.11	
Experience in 3D modeling	BIM	4.90	125.81	0.006*
	Non-BIM	5.26	152.01	
Experience from design	BIM	4.80	136.03	0.315
	Non-BIM	4.90	145.86	
Experience from production	BIM	4.67	151.30	0.202
	Non-BIM	4.48	138.65	
3D modeling education	BIM	4.18	97.41	0.531
	Non-BIM	4.30	102.76	
Worked with computer technology/ IT	BIM	4.03	94.33	0.243
	Non-BIM	4.21	104.26	
Experience from project management	BIM	3.92	95.64	0.343
	Non-BIM	4.13	103.62	
Construction engineering Education (BSc)	BIM	3.35	139.88	0.638
	Non-BIM	3.43	144.64	
Computer engineering/ IT education	BIM	2.91	126.58	0.013*
	Non-BIM	3.40	151.60	
Civil engineering education	BIM	2.50	134.76	0.210
	Non-BIM	2.73	147.32	
Architectural education	BIM	2.00	91.56	0.094
	Non-BIM	2.37	105.61	

**Test is significant at p-value (probability value) <0.05*

4.3 Tasks

The list of tasks in the survey was based on the literature overview. Some tasks were perceived as more important and higher valued for BIM actors than others. The most important tasks that all respondents agreed upon were: model creation and maintaining the 3D model, quality assurance of the model, and compiling BIM experiences from the project (see Table 6). However, the results of the Mann-Whitney test showed that BIM and non-BIM actors had significantly different opinions on six tasks that a BIM actor should carry out. BIM actors felt more strongly than non-BIM actors that establishing and maintaining a coordination model, making collision checks, maintaining BIM requirements, participating in consultancy procurement, compiling BIM experiences from the project and supporting cooperation through visualization of the model are important tasks of a BIM actor. The Mann-Whitney test between the BIM strategist and BIM coordinator shows a significant difference for two items: the BIM strategist considers performing cost calculations more important, while BIM coordinators feel that improving /supporting communication is more important.

Table 6. The means and Mann-Whitney test for tasks expected to be carried out by a BIM actor (only significant tasks are presented)

Tasks	Role	Mean values	Mean ranks	p-value
Establish and maintain coordination model	BIM	5.48	161.23	0.005*
	Non-BIM	5.13	135.06	
Model clash detection	BIM	5.46	160.61	0.007*
	Non-BIM	5.20	135.39	
Compile BIM experiences from the project	BIM	5.34	156.90	0.040*
	Non-BIM	5.12	137.31	
Support cooperation through visualization of the model	BIM	5.34	162.21	0.004*
	Non-BIM	4.93	134.56	
Maintain BIM requirements	BIM	5.05	161.28	0.005*
	Non-BIM	4.94	134.38	
Participate in consultancy procurement	BIM	4.30	159.97	0.017*
	Non-BIM	3.90	135.72	

** Test is significant at p-value (probability value) <0.05*

4.4 Structural and cultural systems upholding the BIM actor role

Many perceive the BIM actor to be important for the success of a project (64.3 percent high to very high importance), and many also felt that the role will become more or significantly more important in the future (90.5 percent). The Mann-Whitney tests revealed that BIM and non-BIM actors had significantly different opinions regarding two of the statements about BIM (see Table 7). BIM actors felt more strongly than non-BIM actors that the BIM actor is an important role for the success of a project and that the BIM actor role will become more important in the future. There were no significant differences between BIM strategist and BIM coordinators.

Table 7. The means and Mann-Whitney test for perceptions on the development of the role

Development of the role	Role	Mean values	Mean ranks	p-value
What importance do you think the BIM actor has for the success of a project.[1]	BIM	4.87	158.30	0.022*
	Non-BIM	4.58	135.78	
How do you think the BIM role will develop in the future?[2]	BIM	4.50	111.27	0.030*
	Non-BIM	4.32	94.41	

** Test is significant at p-value (probability value) <0.05*

1) Scale from: 1= 'very low extent' to 6= 'very high extent'

2) Scale from: 1='will disappear', 2='becomes less important, 3='maintains same meaning', 4='becomes more important, 5='be much more important'.

Concerning the role of the BIM actor, all respondents view that the company has defined the role to some extent; mean of 3.66 on a scale from 1 = not defined and 6 = very well defined. Participants from different companies had different opinions on the clarity of definition of what a BIM actor should do in a project; mean values are 4.07 for architects, 3.55 for contractors and 3.31 for clients. There was no significant difference between BIM (mean 3.75) and non-BIM actors (mean 3.61) regarding whether their company clearly defined what a BIM actor should do in a project.

The main hindrance for the development of the role of the BIM actor was identified as the lack of competence and knowledge of BIM from other employees (mean BIM 4.55, non-BIM 4.58). Other major hindrances were a lack of time (mean BIM 4.46, non-BIM 4.18) and a lack of experience among the BIM coordinators (mean BIM 4.15, non-BIM 4.22). The Mann-Whitney test showed that BIM and non-BIM actors had significantly different opinions about two of the barriers: insufficient management support and unclear career development (see Table 8). BIM actors, more than non-BIM actors, found insufficient management support a barrier, while non-BIM actors found unclear career development a barrier. There were no significant differences between BIM strategist and BIM coordinators.

Table 8. The means and Mann-Whitney test for barriers of the development of BIM actor role

Barriers	**Role**	**Mean values**	**Mean ranks**	**p-value**
Insufficient management support	BIM	4.47	113.73	0.020*
	Non-BIM	3.99	93.98	
Unclear career development	BIM	2.85	71.70	0.002*
	Non-BIM	3.44	95.60	

** Test is significant at p-value (probability value) <0.05*

5 Discussion

This paper presents a study on how the BIM actor role develops as a professional role in Sweden. The study relates the perspectives of BIM actors with those of non-BIM actors to compare how the two groups perceive role development. In order to analyze this, the study focused on gaining insight into the characteristics and expectations of a particular role engagement from the BIM actors themselves (insider perspective), as well as how non-BIM actors (outsider perspective) perceive BIM actors. Thus, insights were gained into how actors are understood as practitioners of working with BIM by themselves, but also by others [10]. From the literature review two main elements of role professionalization for BIM actors were studied: (A) *the expected competences* concerning characteristics, education, experience and practiced tasks from a BIM actor by BIM actors themselves and non-BIM actors, and (B) *the*

structural and organizational systems that influence the professionalization of the BIM actor role. Both elements are discussed in literature toward the development and institutionalization of a profession and its identity [10,15].

Competency, as defined by Succar, Sher and Williams [18], consisted of three measured parts: the characteristics of a BIM actor, the theoretical knowledge and skills, and the tasks performed. The respondents ranked having good interpersonal skills, showing commitment, and being structured as the most important characteristics of a BIM actor. However, there were also significant differences in that BIM actors, more than non-BIM actors, expect that a BIM actor should have good communication skills, have a strong driving force, be able to make demands, be patient, be curious, and be change-oriented. Being a strong driving force, being able to make demands, and being change-oriented are especially relevant since they could increase possible tension regarding how the BIM actors see their role as a driving role that could support change. The non-BIM actors do not perceive the BIM actors as such change agents.

From the data, we found that both BIM and non-BIM actors expect that a BIM actor should primarily understand the construction process. BIM actors also think that a BIM actor should understand the needs of different professional groups. Both groups find education less important than experience. The results showed that non-BIM actors, more than BIM actors, expect that a BIM actor should have experience in 3D modeling and education of computer engineering and IT. The perspective of the non-BIM actors is in line with earlier studies regarding the importance of education for implementing BIM [21,22]. Actors who work with BIM perceive specific education as less important than non-BIM actors do. This tension might be in line with the perception of the BIM actors in being drivers for change and seeing themselves more as coordinators, meaning that they would need soft skills for collaboration and communication. However, non-BIM actors perceive BIM actors more as people who establish and maintain 3D models, meaning that they would need technical skills. The literature concerning BIM actors discusses multiple tasks but does not present a unified picture on the main tasks of a BIM actor [6, 7, 8]. The present study supports this argument: while all tasks seem to be relevant for BIM strategists/experts, BIM coordinators, and non-BIM actors; there were significant differences between BIM actors and non-BIM actors. Both BIM and non-BIM actors ranked model creation and maintaining the 3D model and model clash detection in their top three tasks of a BIM actor. While BIM actors felt that maintaining BIM requirements was one of the three most important tasks, non-BIM actors ranked quality assurance of the model in their top three tasks. The results showed that BIM actors, more than non-BIM actors, feel

that establishing and maintaining a coordination model, making collision checks, maintaining BIM requirements, participating in consultancy procurement, compiling BIM experiences from the project, and supporting cooperation through visualization of the model are all important tasks of a BIM actor. The difference in expectations concerning tasks that should be performed by a BIM actor provides insight into how different groups perceive the BIM role. While BIM actors see their role as including both technical and managerial tasks, non-BIM actors limit tasks of a BIM actor to mainly technical tasks. A possible explanation for the significant difference between the expectations of the BIM actor's tasks might be based on the respondents' different professional disciplines. The tasks stated in the literature are primarily focused on design and, to some extent, construction, but less on facility management and maintenance, which some of our respondents have as their main business. Therefore, a more detailed study on specific tasks for different stakeholders would be beneficial for future research.

The second part that is relevant for the development and institutionalization of a BIM profession is the structural and cultural systems upholding a profession [10]. The data shows that there is a future for the role; the role is to some extent defined in the studied firms, but there are still some organizational hindrances that can influence the future development of the role. It is widely perceived that BIM actors are important for the success of a project and also that the role will become more or much more important in the future. However, there was a significant difference in the answers and BIM actors, more than non-BIM actors, perceived their role as relevant to the success of a project, as well as becoming more important in the future. This difference could be explained by the fact that BIM actors view their role as relevant and identify with this role. The difference in perception of the BIM actors influences the meaning-making process of a professional role identity [17]. Furthermore, the definition of the role of the BIM actors was described to some extent and both groups agreed on this. This confirms that there is no unified view on the role, responsibilities, and tasks of a BIM actor nor their education and experiences, which is in line with earlier studies [6, 7, 8]. We can also see from the data that the naming of BIM actor roles in Sweden is different per company as well as different from other countries; for example, in Sweden, the roles of BIM strategist and BIM coordinator are mainly used. Furthermore, the similarities in answers from these two groups also indicates that the two roles for BIM are not as clearly defined within the firms and that BIM actors have tasks that could fit for both BIM strategists and BIM coordinators depending on the firm. In our sample, 28 respondents mentioned they work both as BIM strategists and

coordinators, which might be the case for smaller and medium-sized AEC firms due to a lack of resources.

The main hindrances identified for the development of the role of the BIM actor were a lack of competence in BIM from other employees, a lack of time, a lack of experience of BIM actors, and insufficient management support. Especially, BIM actors felt that they lacked management support for the professional development of their role. The possible consequences for the perception of lack of management support could create tensions for the development of the BIM actor role. Management support could influence the development in terms of tasks and responsibilities, description of the role, and the future development of such a professional role.

6 Conclusion

In conclusion, we find that the data from this study provides insights into the current perception of the BIM actor role in the Swedish AEC context. The similarities and differences in perceptions of the BIM actor role are in line with literature on professional roles and identity. Professional roles and their development are dependent on the expectation of the professionals as well as the surroundings that work with the professional roles. The perceived differences between the BIM and non-BIM actors could portray the institutionalization process of the new role of the BIM actor in which the BIM actor is a change agent towards the use of BIM in the industry and the non-BIM actors maintaining the current norms and values of the industry. The professional role of a BIM actor can function as an institutional agent in terms of defining, translating, and applying institutional aspects [15]. The professional role of a BIM actor can only become institutionalized when the industry recognizes the role, its tasks and responsibilities, and defines the role more clearly. Our data confirms that this is the case for the Swedish AEC industry and that the BIM actor role is an accepted role within the industry, even though clarity is required concerning tasks and responsibility.

This study offers empirical insights into the development of BIM actor roles in Sweden by contrasting the perspectives of BIM and non-BIM actors in the Swedish AEC industry through a survey study. We found that BIM actors perceive their role, characteristics, tasks, and education as coordinating and driving change, which means that softer skills become relevant. However, non-BIM actors perceive the BIM actor role as a more technical role that focuses on technical skills. The differences perceived by the two groups highlight tensions in relation to the future development and institutionalization of the BIM actor role.

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